

What is claimed is:

1           1.     A method for repairing a pattern using a laser  
2 comprising:

3           a step of using laser light emitted from a Q-switched  
4 mode-locked pulse laser as laser light to be applied for repair  
5 processing.

1           2.     The method for repairing the pattern using the laser  
2 according to Claim 1, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1           3.     A method for repairing a pattern using a laser  
2 comprising:

3           a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser by using an optical modulator  
6 and using said laser light having said sliced single pulse or said  
7 sliced multi-laser pulses as laser light to be applied for repair  
8 processing.

1           4.     The method for repairing the pattern using the laser  
2 according to Claim 3, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1           5.     The method for repairing the pattern using the laser  
2 according to Claim 3, wherein the number of said multi-laser pulses

3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1 6. A method for repairing a pattern using a laser  
2 comprising:

3 a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser by using an optical modulator;  
6 and

7 a step of directly amplifying said laser light having said  
8 sliced single laser pulse or said sliced multi-laser pulses by  
9 using an optical amplifier and using said amplified laser light  
10 as laser light to be applied for repair processing.

1 7. The method for repairing the pattern using the laser  
2 according to Claim 6, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1 8. The method for repairing the pattern using the laser  
2 according to Claim 6, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1 9. A method for repairing a pattern using a laser

2 comprising:

3 a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;  
6 and

7 a step of multiplexing one laser light having a first laser  
8 pulse obtained by splitting said single laser pulse or said  
9 multi-laser pulses and an other laser light having a second laser  
10 pulse obtained by splitting said single laser pulse or said  
11 multi-laser pulses and by providing time delay to said second laser  
12 pulse into one laser light and using said multiplexed laser light  
13 as laser light to be applied for repair processing.

1 10. The method for repairing the pattern using the laser  
2 according to Claim 9, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1 11. The method for repairing the pattern using the laser  
2 according to Claim 10, wherein said time delay between said first  
3 laser pulse and said second laser pulse is in a range of 0.1  
4 nanoseconds to 9 nanoseconds.

1 12. The method for repairing the pattern using the laser  
2 according to Claim 9, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1        13. A method for repairing a pattern using a laser  
2 comprising:

3        a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;

6        a step of multiplexing one laser light having a first laser  
7 pulse obtained by splitting said single laser pulse or said  
8 multi-laser pulses and an other laser light having a second laser  
9 pulse obtained by splitting said single laser pulse or said  
10 multi-laser pulses and by providing time delay to said second laser  
11 pulse into one laser light; and

12        a step of directly amplifying said multiplexed laser light  
13 by using an optical amplifier and using said amplified laser light  
14 as laser light to be applied for repair processing.

1        14. The method for repairing the pattern using the laser  
2 according to Claim 13, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1        15. The method for repairing the pattern using the laser  
2 according to Claim 13, wherein said time delay between said first  
3 laser pulse and said second laser pulse is in a range of 0.1  
4 nanoseconds to 10 nanoseconds.

1        16. The method for repairing the pattern using the laser  
2 according to Claim 13, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser

5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1 17. A method for repairing a pattern using a laser  
2 comprising:

3 a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;  
6 and

7 a step of converting a wavelength of laser light having said  
8 sliced single pulse or said sliced multi-laser pulses to produce  
9 harmonic light and using said harmonic light as laser light to  
10 be applied for repair processing.

1 18. The method for repairing the pattern using the laser  
2 according to Claim 17, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1 19. The method for repairing the pattern using the laser  
2 according to Claim 17, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1 20. A method for repairing a pattern using a laser  
2 comprising:

3 a step of slicing a single laser pulse or multi-laser pulses

4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;  
6 a step of multiplexing one laser light having a first laser  
7 pulse obtained by splitting said single laser pulse or said  
8 multi-laser pulses and an other laser light having a second laser  
9 pulse obtained by splitting said single laser pulse or said  
10 multi-laser pulses and by providing time delay to said second laser  
11 pulse into one laser light; and  
12 a step of converting a wavelength of said multiplexed laser  
13 light to produce harmonic light and using said harmonic light as  
14 laser light to be applied for repair processing.

1 21. The method for repairing the pattern using the laser  
2 according to Claim 20, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1 22. The method for repairing the pattern using the laser  
2 according to Claim 20, wherein said time delay between said first  
3 laser pulse and said second laser pulse is in a range of 0.1  
4 nanoseconds to 10 nanoseconds.

1 23. The method for repairing the pattern using the laser  
2 according to Claim 20, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1        24.    A method for repairing a pattern using a laser  
2 comprising:

3        a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;

6        a step of directly amplifying laser light having said sliced  
7 single laser pulse or said sliced multi-laser pulses using an  
8 optical amplifier; and

9        a step of converting a wavelength of said amplified laser  
10 light to produce harmonic light and using said harmonic light as  
11 laser light to be applied for repair processing.

1        25.    The method for repairing the pattern using the laser  
2 according to Claim 24, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1        26.    The method for repairing the pattern using the laser  
2 according to Claim 24, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.

1        27.    A method for repairing a pattern using a laser  
2 comprising:

3        a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;

6 a step of multiplexing one laser light having a first laser  
7 pulse obtained by splitting said single laser pulse or said  
8 multi-laser pulses and an other laser light having a second laser  
9 pulse obtained by splitting said single laser pulse or said  
10 multi-laser pulses and by providing time delay to said second laser  
11 pulse into one laser light;

12 a step of directly amplifying said multiplexed laser light  
13 by using an optical amplifier; and

14 a step of converting a wavelength of said amplified laser  
15 light to produce harmonic light and using said harmonic light as  
16 laser light to be applied for repair processing.

1 28. The method for repairing the pattern using the laser  
2 according to Claim 27, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1 29. The method for repairing the pattern using the laser  
2 according to Claim 27, wherein said time delay between said first  
3 laser pulse and said second laser pulse is in a range of 0.1  
4 nanoseconds to 10 nanoseconds.

1 30. The method for repairing the pattern using the laser  
2 according to Claim 27, wherein the number of said multi-laser pulses  
3 to be sliced from said laser light emitted from said Q-switched  
4 mode-locked pulse laser and time to start slicing said multi-laser  
5 pulses to obtain a first pulse are able to be set in an arbitrary  
6 manner.



1           31. A method for repairing a pattern using a laser  
2 comprising:

3           a step of slicing a single laser pulse or multi-laser pulses  
4 from a string of pulses making up laser light emitted from a  
5 Q-switched mode-locked pulse laser using an optical modulator;

6           a step of directly amplifying laser light having said sliced  
7 single laser pulse or sliced multi-laser pulse by using an optical  
8 amplifier;

9           a step of multiplexing one amplified laser light having a  
10 first laser pulse obtained by splitting said single laser pulse  
11 or said multi-laser pulses and another amplified laser light having  
12 a second laser pulse obtained by splitting said single laser pulse  
13 or said multi-laser pulses and by providing time delay to said  
14 second laser pulse into one laser light;

15           a step of directly amplifying said multiplexed laser light  
16 by using an optical amplifier; and

17           a step of converting a wavelength of said amplified laser  
18 light to produce harmonic light and using said harmonic light as  
19 laser light to be applied for repair processing.

1           32. The method for repairing the pattern using the laser  
2 according to Claim 31, wherein a pulse width of said laser light  
3 to be applied for said repair processing is in a range of 10  
4 picoseconds to 300 picoseconds.

1           33. The method for repairing the pattern using the laser  
2 according to Claim 31, wherein said time delay between said first  
3 laser pulse and said second laser pulse is in a range of 0.1  
4 nanoseconds to 10 nanoseconds.

1           34.    The method for repairing the pattern using the laser  
2   according to Claim 31, wherein the number of said multi-laser pulses  
3   to be sliced from said laser light emitted from said Q-switched  
4   mode-locked pulse laser and time to start slicing said multi-laser  
5   pulses to obtain a first pulse are able to be set in an arbitrary  
6   manner.

1           35.    A laser-based pattern repair apparatus comprising:  
2           a Q-switched mode-locked pulse laser to emit laser light  
3   to be applied for repair processing.

1           36.    The laser-based pattern repair apparatus according  
2   to Claim 35, wherein said Q-switched mode-locked pulse laser is  
3   made up of a laser resonator having a semiconductor laser pumping  
4   unit or a lamp pumping unit, a laser medium including any one of  
5   a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6   Q-switching element to produce Q-switched pulses, an ultrasonic  
7   mode-locker to produce mode-locked pulses, and etalon plates used  
8   to select a longitudinal mode of said laser resonator.

1           37.    The laser-based pattern repair apparatus according  
2   to Claim 36, wherein said laser resonator is provided therein with  
3   a plurality of etalon plates each having a different thickness  
4   and a remote controller for operating said etalon plates, whereby  
5   said etalon plates each having said different thickness are  
6   changeably inserted into said laser resonator and disposed on a  
7   optical axis thereof.

1           38.    The laser-based pattern repair apparatus according

2 to Claim 37, wherein a variable range of a pulse width of laser  
3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 39. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser; and  
6 wherein laser light emitted from said optical modulator is used  
7 as laser light to be applied for repair processing.

1 40. The laser-based pattern repair apparatus according  
2 to Claim 39, wherein said Q-switched mode-locked pulse laser is  
3 made up of a laser resonator having a semiconductor laser pumping  
4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 41. The laser-based pattern repair apparatus according  
2 to Claim 40, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1           42.    The laser-based pattern repair apparatus according  
2   to Claim 41, wherein a variable range of a pulse width of laser  
3   light that is able to be obtained by switching for inserting said  
4   etalon plates is 10 picoseconds to 300 picoseconds.

1           43.    The laser-based pattern repair apparatus according  
2   to Claim 39, wherein, when said multi-laser pulses are sliced by  
3   said optical modulator from laser light emitted from said  
4   Q-switched mode-locked pulse laser, the number of said multi-laser  
5   pulses to be sliced and time to start slicing a first pulse are  
6   able to be arbitrarily set and to be operated by remote control.

1           44.    A laser-based pattern repair apparatus comprising:  
2           a Q-switched mode-locked pulse laser;  
3           an optical modulator to slice a single laser pulse or  
4   multi-laser pulses from a string of pulses contained in laser light  
5   emitted from said Q-switched mode-locked pulse laser;  
6           an optical amplifier to directly amplify laser light having  
7   said sliced single laser pulse or said sliced multi-laser pulses  
8   emitted from said optical modulator; and  
9           wherein laser light emitted from said optical amplifier is  
10   used as laser light to be applied for repair processing.

1           45.    The laser-based pattern repair apparatus according  
2   to Claim 44, wherein said Q-switched mode-locked pulse laser is  
3   made up of a laser resonator having a semiconductor laser pumping  
4   unit or a lamp pumping unit, a laser medium including any one of  
5   a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6   Q-switching element to produce Q-switched pulses, an ultrasonic

7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 46. The laser-based pattern repair apparatus according  
2 to Claim 45, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 47. The laser-based pattern repair apparatus according  
2 to Claim 46, wherein a variable range of a pulse width of laser  
3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 48. The laser-based pattern repair apparatus according  
2 to Claim 44, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said  
4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 49. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 a laser pulse multiplexing and delaying unit to multiplex

7 one amplified laser light having a first laser pulse obtained by  
8 splitting said single laser pulse or said multi-laser pulses and  
9 another amplified laser light having a second laser pulse obtained  
10 by splitting said single laser pulse or said multi-laser pulses  
11 and by providing time delay to said second laser pulse into one  
12 laser light; and

13 wherein laser light emitted from said laser pulse  
14 multiplexing and delaying unit is used as laser light to be applied  
15 for repair processing.

1 50. The laser-based pattern repair apparatus according  
2 to Claim 49, wherein said Q-switched mode-locked pulse laser is  
3 made up of a laser resonator having a semiconductor laser pumping  
4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 51. The laser-based pattern repair apparatus according  
2 to Claim 50, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 52. The laser-based pattern repair apparatus according  
2 to Claim 51, wherein a variable range of a pulse width of laser

3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 53. The laser-based pattern repair apparatus according  
2 to Claim 49, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said  
4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 54. The laser-based pattern repair apparatus according  
2 to Claim 49, wherein said laser pulse multiplexing and delaying  
3 unit is able to change said delay time within a range of 0.1  
4 nanoseconds to 10 nanoseconds and said change of said delay time  
5 is able to be implemented by remote control.

1 55. The laser-based pattern repair apparatus according  
2 to Claim 49, wherein an intensity of a peak power of said first  
3 laser pulse and said second laser pulse to be multiplexed and delayed  
4 by said laser pulse multiplexing and delaying unit is able to be  
5 controlled and calibrated by remote control.

1 56. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 a laser pulse multiplexing and delaying unit to multiplex  
7 one amplified laser light having a first laser pulse obtained by

8 splitting said single laser pulse or said multi-laser pulses and  
9 another amplified laser light having a second laser pulse obtained  
10 by splitting said single laser pulse or said multi-laser pulses  
11 and by providing time delay to said second laser pulse into one  
12 laser light;

13 an optical amplifier to directly amplify said multiplexed  
14 laser light; and

15 wherein laser light emitted from said optical amplifier is  
16 used as laser light to be applied for repair processing.

1 57. The laser-based pattern repair apparatus according  
2 to Claim 56, wherein said Q-switched mode-locked pulse laser is  
3 made up of a laser resonator having a semiconductor laser pumping  
4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 58. The laser-based pattern repair apparatus according  
2 to Claim 57, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 59. The laser-based pattern repair apparatus according  
2 to Claim 58, wherein a variable range of a pulse width of laser



3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 60. The laser-based pattern repair apparatus according  
2 to Claim 56, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said  
4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 61. The laser-based pattern repair apparatus according  
2 to Claim 56, wherein said laser pulse multiplexing and delaying  
3 unit is able to change said delay time within a range of 0.1  
4 nanoseconds to 10 nanoseconds and said change of said delay time  
5 is able to be implemented by remote control.

1 62. The laser-based pattern repair apparatus according  
2 to Claim 56, wherein an intensity of a peak power of said first  
3 laser pulse and said second laser pulse to be multiplexed and delayed  
4 by said laser pulse multiplexing and delaying unit is able to be  
5 controlled and calibrated by remote control.

1 63. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 a wavelength converting unit to convert a wavelength of laser  
7 light having said sliced single pulse or said sliced multi-laser

8 pulses to produce harmonic light; and  
9 wherein laser light emitted from said wavelength converting  
10 unit is used as laser light to be applied for repair processing.

1 64. The laser-based pattern repair apparatus according  
2 to Claim 63, wherein said Q-switched mode-locked pulse laser is  
3 made up of a laser resonator having a semiconductor laser pumping  
4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 65. The laser-based pattern repair apparatus according  
2 to Claim 64, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 66. The laser-based pattern repair apparatus according  
2 to Claim 65, wherein a variable range of a pulse width of laser  
3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 67. The laser-based pattern repair apparatus according  
2 to Claim 63, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said

4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 68. The laser-based pattern repair apparatus according  
2 to Claim 63, wherein said wavelength converting unit is a wavelength  
3 converting element using a nonlinear optical crystal to emit a  
4 third harmonic, fourth harmonic, and fifth harmonic each having  
5 a wavelength of not more than 360 nm.

1 69. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 a laser pulse multiplexing and delaying unit to multiplex  
7 one laser light having a first laser pulse obtained by splitting  
8 said single laser pulse or said multi-laser pulses and an other  
9 laser light having a second laser pulse obtained by splitting said  
10 single laser pulse or said multi-laser pulses and by providing  
11 time delay to said second laser pulse into one laser light;  
12 a wavelength converting unit to convert a wavelength of said  
13 multiplexed laser light to produce harmonic light; and  
14 wherein laser light emitted from said wavelength converting  
15 unit is used as laser light to be applied for repair processing.

1 70. The laser-based pattern repair apparatus according  
2 to Claim 69, wherein said Q-switched mode-locked pulse laser is  
3 made up of a laser resonator having a semiconductor laser pumping

4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 71. The laser-based pattern repair apparatus according  
2 to Claim 70, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 72. The laser-based pattern repair apparatus according  
2 to Claim 71, wherein a variable range of a pulse width of laser  
3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 73. The laser-based pattern repair apparatus according  
2 to Claim 69, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said  
4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 74. The laser-based pattern repair apparatus according  
2 to Claim 69, wherein said laser pulse multiplexing and delaying  
3 unit is able to change said delay time within a range of 0.1

4 nanoseconds to 10 nanoseconds and said change of said delay time  
5 is able to be implemented by remote control.

1 75. The laser-based pattern repair apparatus according  
2 to Claim 69, wherein an intensity of a peak power of said first  
3 laser pulse and said second laser pulse to be multiplexed and delayed  
4 by said laser pulse multiplexing and delaying unit is able to be  
5 controlled and calibrated by remote control.

1 76. The laser-based pattern repair apparatus according  
2 to Claim 69, wherein said wavelength converting unit is a wavelength  
3 converting element using a nonlinear optical crystal to emit a  
4 third harmonic, fourth harmonic, and fifth harmonic each having  
5 a wavelength of not more than 360 nm.

1 77. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 an optical amplifier to directly amplify said laser light  
7 having said sliced single laser pulse or said sliced multi-laser  
8 pulses;  
9 a wavelength converting unit to convert a wavelength of laser  
10 light emitted from said optical amplifier to produce harmonic  
11 light; and  
12 wherein laser light emitted from said wavelength converting  
13 unit is used as laser light to be applied for repair processing.

1           78.    The laser-based pattern repair apparatus according  
2   to Claim 77, wherein said Q-switched mode-locked pulse laser is  
3   made up of a laser resonator having a semiconductor laser pumping  
4   unit or a lamp pumping unit, a laser medium including any one of  
5   a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6   Q-switching element to produce Q-switched pulses, an ultrasonic  
7   mode-locker to produce mode-locked pulses, and etalon plates used  
8   to select a longitudinal mode of said laser resonator.

1           79.    The laser-based pattern repair apparatus according  
2   to Claim 78, wherein said laser resonator is provided therein with  
3   a plurality of etalon plates each having a different thickness  
4   and a remote controller for operating said etalon plates, whereby  
5   said etalon plates each having said different thickness are  
6   changeably inserted into said laser resonator and disposed on a  
7   optical axis thereof.

1           80.    The laser-based pattern repair apparatus according  
2   to Claim 79, wherein a variable range of a pulse width of laser  
3   light that is able to be obtained by switching for inserting said  
4   etalon plates is 10 picoseconds to 300 picoseconds.

1           81.    The laser-based pattern repair apparatus according  
2   to Claim 77, wherein, when said multi-laser pulses are sliced by  
3   said optical modulator from laser light emitted from said  
4   Q-switched mode-locked pulse laser, the number of said multi-laser  
5   pulses to be sliced and time to start slicing a first pulse are  
6   able to be arbitrarily set and to be operated by remote control.

1           82.    The laser-based pattern repair apparatus according  
2   to Claim 77, wherein said wavelength converting unit is a wavelength  
3   converting element using a nonlinear optical crystal to emit a  
4   third harmonic, fourth harmonic, and fifth harmonic each having  
5   a wavelength of not more than 360 nm.

1           83.    A laser-based pattern repair apparatus comprising:  
2           a Q-switched mode-locked pulse laser;  
3           an optical modulator to slice a single laser pulse or  
4   multi-laser pulses from a string of pulses contained in laser light  
5   emitted from said Q-switched mode-locked pulse laser;  
6           a laser pulse multiplexing and delaying unit to multiplex  
7   one laser light having a first laser pulse obtained by splitting  
8   said sliced single laser pulse or said sliced multi-laser pulses  
9   and an other laser light having a second laser pulse obtained  
10   by splitting said sliced single laser pulse or said sliced  
11   multi-laser pulses and by providing time delay to said second laser  
12   pulse into one laser light;  
13          an optical amplifier to directly amplify said multiplexed  
14   laser light;  
15          a wavelength converting unit to convert a wavelength of laser  
16   light emitted from said optical amplifier to produce harmonic  
17   light; and  
18          wherein laser light emitted from said wavelength converting  
19   unit is used as laser light to be applied for repair processing.

1           84.    The laser-based pattern repair apparatus according  
2   to Claim 83, wherein said Q-switched mode-locked pulse laser is  
3   made up of a laser resonator having a semiconductor laser pumping

4 unit or a lamp pumping unit, a laser medium including any one of  
5 a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
6 Q-switching element to produce Q-switched pulses, an ultrasonic  
7 mode-locker to produce mode-locked pulses, and etalon plates used  
8 to select a longitudinal mode of said laser resonator.

1 85. The laser-based pattern repair apparatus according  
2 to Claim 84, wherein said laser resonator is provided therein with  
3 a plurality of etalon plates each having a different thickness  
4 and a remote controller for operating said etalon plates, whereby  
5 said etalon plates each having said different thickness are  
6 changeably inserted into said laser resonator and disposed on a  
7 optical axis thereof.

1 86. The laser-based pattern repair apparatus according  
2 to Claim 85, wherein a variable range of a pulse width of laser  
3 light that is able to be obtained by switching for inserting said  
4 etalon plates is 10 picoseconds to 300 picoseconds.

1 87. The laser-based pattern repair apparatus according  
2 to Claim 83, wherein, when said multi-laser pulses are sliced by  
3 said optical modulator from laser light emitted from said  
4 Q-switched mode-locked pulse laser, the number of said multi-laser  
5 pulses to be sliced and time to start slicing a first pulse are  
6 able to be arbitrarily set and to be operated by remote control.

1 88. The laser-based pattern repair apparatus according  
2 to Claim 83, wherein said laser pulse multiplexing and delaying  
3 unit is able to change said delay time within a range of 0.1



4 nanoseconds to 10 nanoseconds and said change of said delay time  
5 is able to be implemented by remote control.

1 89. The laser-based pattern repair apparatus according  
2 to Claim 83, wherein an intensity of a peak power of said first  
3 laser pulse and said second laser pulse to be multiplexed and delayed  
4 by said laser pulse multiplexing and delaying unit is able to be  
5 controlled and calibrated by remote control.

1 90. The laser-based pattern repair apparatus according  
2 to Claim 83, wherein said wavelength converting unit is a wavelength  
3 converting element using a nonlinear optical crystal to emit a  
4 third harmonic, fourth harmonic, and fifth harmonic each having  
5 a wavelength of not more than 360 nm.

1 91. A laser-based pattern repair apparatus comprising:  
2 a Q-switched mode-locked pulse laser;  
3 an optical modulator to slice a single laser pulse or  
4 multi-laser pulses from a string of pulses contained in laser light  
5 emitted from said Q-switched mode-locked pulse laser;  
6 a laser pulse multiplexing, delaying, and amplifying unit  
7 to multiplex one laser light having a first laser pulse obtained  
8 by splitting said sliced single laser pulse or said sliced  
9 multi-laser pulses and an other amplified laser light having a  
10 second laser pulse obtained by splitting said sliced single laser  
11 pulse or said sliced multi-laser pulses and by providing time delay  
12 to said second laser pulse into one laser light and, at the same  
13 time, to directly amplify laser light having said first laser pulse  
14 by a double pass method in which said laser light is transmitted

15 twice through an optical amplifying medium in a reciprocating  
16 manner and to directly amplify laser light having said second laser  
17 pulse by a single pass method in which said laser light is transmitted  
18 once through said optical amplifying medium;

19 a wavelength converting unit to convert a wavelength of laser  
20 light emitted from said laser pulse multiplexing, delaying, and  
21 amplifying unit to produce harmonic light; and

22 wherein laser light emitted from said wavelength converting  
23 unit is used as laser light to be applied for repair processing.

92. The laser-based pattern repair apparatus according  
to Claim 91, wherein said Q-switched mode-locked pulse laser is  
made up of a laser resonator having a semiconductor laser pumping  
unit or a lamp pumping unit, a laser medium including any one of  
a Nd:YLF laser, Nd:YAG laser and Nd:glass laser, an ultrasonic  
Q-switching element to produce Q-switched pulses, an ultrasonic  
mode-locker to produce mode-locked pulses, and etalon plates used  
to select a longitudinal mode of said laser resonator.

93. The laser-based pattern repair apparatus according  
to Claim 92, wherein said laser resonator is provided therein with  
a plurality of etalon plates each having a different thickness  
and a remote controller for operating said etalon plates, whereby  
said etalon plates each having said different thickness are  
changeably inserted into said laser resonator and disposed on a  
optical axis thereof.

94. The laser-based pattern repair apparatus according  
to Claim 93, wherein a variable range of a pulse width of laser

light that is able to be obtained by switching for inserting said etalon plates is 10 picoseconds to 300 picoseconds.

95. The laser-based pattern repair apparatus according to Claim 91, wherein, when said multi-laser pulses are sliced by said optical modulator from laser light emitted from said Q-switched mode-locked pulse laser, the number of said multi-laser pulses to be sliced and time to start slicing a first pulse are able to be arbitrarily set and to be operated by remote control.

96. The laser-based pattern repair apparatus according to Claim 91, wherein said laser pulse multiplexing, delaying, and amplifying unit is able to change said delay time within a range of 0.1 nanoseconds to 10 nanoseconds and said change of said delay time is able to be implemented by remote control.

97. The laser-based pattern repair apparatus according to Claim 91, wherein an intensity of a peak power of said first laser pulse and said second laser pulse to be multiplexed and delayed by said laser pulse multiplexing and delaying unit; or multiplexed, delayed, and amplified by said laser pulse multiplexing, delaying, and amplifying unit is able to be controlled and calibrated by remote control.

98. The laser-based pattern repair apparatus according to Claim 91, wherein said wavelength converting unit is a wavelength converting element using a nonlinear optical crystal to emit a third harmonic, fourth harmonic, and fifth harmonic each having a wavelength of not more than 360 nm.